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Take-All of Wheat

and

Similar Diseases of Cereals

by

W. M. Carne and J. G. C. Campbell, B.Sc.

Issued by direction of the Hon. H. K. Maley, M.L.A., Minister for Agriculture.

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TAKE-ALL OF WHEAT AND SIMILAR DISEASES OF CEREALS.

(W. M. Carne, Botanist and Pathologist, and J. G. C. Campbell, B.Sc., Assistant.)

TAKE-ALL (Ophiobolus cariceti, also known as **Ophiobolus graminis).**

This important disease, known also as **Footrot, Blackleg,** and **Whiteheads,** affects wheat principally, but also occurs on barley, rye, and certain grasses. In a very few instances it has been known to attack oats, but this is so rare that oats may be regarded for practical purposes as free from attack. Of the grasses attacked the most important, from a farming point of view in Western Australia, are Barley Grass (**Hordeum murinum**), Silver Grass (**Festuca bromoides** and **F. myuros**), and the so-called Spear grasses (**Bromus spp.**). These annual grasses are very common in the wheat belt.

Susceptibility of Wheat Varieties.

So far as is known, all varieties are equally subject to take-all, but definite information on this point is lacking.

Symptoms.

Diseased plants become blighted or withered, turning yellow or greyish white and dying prematurely. If not killed before heading they ripen before the rest of the crop and have little or no grain in the ear. They are frequently stunted and stool badly. A definite feature of the disease is that it usually affects patches of plants. These patches may vary from a few square yards up to several acres in extent. In bad cases the affected patches may aggregate 75 per cent. or more of the crop.

The disease may become evident at any stage of growth, appearing early or late according as it is favoured by the weather conditions. Dry cold weather checks and warm wet weather assists its development. Warm moist springs are particularly liable to be accompanied by an epidemic of the trouble.

In some cases the plants are affected shortly after appearing above ground and may be killed as seedlings. In other cases the effects become noticeable only as the plants approach maturity. Though usually stunted, the growth may at times be practically equal to that of unaffected plants. The premature ripening of such plants, causing them to show up in the crop by their contrasting colour, has caused this development of the disease to be known as "Whiteheads." Grain is rarely produced, and if formed is small and shrivelled.

Occurrence.

Take-all is found in all classes of soil and in all kinds of locations. It occurs on new and old, fallowed and unfallowed land. It is most prevalent in warm moist springs on old continuously worked land, on heavy rather than light soils, and especially in wet ill-drained places, and is more prevalent after grass than after fallow. It is rare on well farmed and well drained properties, where cultivation is thorough and a sound system of farming, which necessarily includes suitable rotations, is practised.

Recognition.

The recognition of take-all is important, as other troubles are frequently mistaken for it, causing farmers to question the efficacy of the control measures recommended. These measures are not effective with other somewhat similar troubles, which are dealt with in another part of this leaflet. Take-all may be recognised by its tendency to occur in patches, combined with a dark brown or black discolouration of the stem bases and the upper parts of the roots. The roots are more or less dead, and there is an abnormal development of woolly root hairs close to the stools. The discolouration extends upwards of an inch from the ground level, and consists of a dark felted layer on the stem and the under surfaces of the lower leaf-sheaths. It can be easily scraped off with the finger nail of a knife blade. A dark discolouration alone at the base of the stems is not a sufficient guide. The lower leaf-sheaths should be removed and the felted covering detected.

Life History of the Fungus.

The black growth on the stems of plants attacked by **Ophiobolus cariceti** consists of interlaced threads called hyphae, which form the fungus plant. Branches from these penetrate the stem, the inner side of the lower leaf-sheaths, and upper parts of the roots. Through these branches they obtain their necessary food from the parasitised wheat plants. If the fungus grows luxuriantly, the attacked parts are killed and the plant soon dies. If conditions are less favourable for the fungus, the plants manage more or less to reach maturity. As the plants die, and the source of food in consequence disappears, the fungus produces spores or seed bodies. These are formed in small black rounded structures, called perithecia, embedded in the tissues of the affected parts. Inside the perithecia are elongated delicate bodies (asci) each containing eight long colourless spores (ascospores). Under suitable conditions of moisture and alterations in humidity, the perithecia discharge the asci, and these in turn release their spores. Under the same conditions which cause their discharge, the spores germinate, that is, they produce root-like growths which are able to attack and penetrate plants subject to take-all if the latter are present. Infection of a crop is due to the spores formed on infected plants previously growing on the same soil, or spores from neighbouring affected areas, or from headlands, etc. To some extent, infection may take place from the felted growth on fragments of infected plants blown about the soil or mixed with and sown with grain. It is known that the spores enclosed in the perithecia may live several years if undischarged, and the most probable means of infection is the carriage of these perithecia on plant fragments by wind, animals, cultivation, etc., from infected plants throughout the paddocks. The area of infection, if no control measures are adopted, consequently increases annually.

Evidence is increasing that the take-all fungus most readily attacks plants weakened by being grown in badly prepared or badly drained soil and in soil which, from lack of sufficient manuring with fertilisers, contains insufficient plant food. It has also been shown that the fungus prefers alkaline conditions and it is possible that the use of an acid fertiliser such as superphosphate may

have a direct action against it as well as increasing the vigour and resistance of the crop.

Attention must be drawn to two points:

Firstly, for the discharge and germination of the spores, moisture is necessary.

Secondly, for infection, suitable plants must be handy to the spores when they germinate.

On these two points our methods of control are based. We must, if possible, insure the presence of moisture in contact with the perithecia to secure the germination of the spores, and at the same time we must endeavour to prevent the presence of susceptible plants until the spores have died from lack of plants to parasitise.

Control Measures.

It must be realised, of course, that it is not possible to secure 100 per cent. efficiency in carrying out the advice that follows, but it has been fully demonstrated that the more closely the recommendations given below are followed, the less the danger of serious results from this disease. Except in ill-drained soils, there is no reason other than bad farming why in any season this disease should cause serious loss.

The main lines of treatment are:—

1. Burn the stubble of badly affected crops. This will reduce the number of spores, but will not destroy them all, as many on the lowest parts of the stems escape uninjured.
2. Fallow early. Plough in the early winter so that perithecia on stubble or on the soil are turned into moist soil to induce them to discharge their spores and the spores to germinate.
3. Keep the fallows clean with both sheep and cultivation, so that the spores on germinating have nothing to attack and die from starvation. Allowing an infected area to revert to pasture is not advisable, for take-all can live on volunteer wheat and on the barley and spear grasses which appear so readily in the wheat belt. It must also be remembered that these grasses growing on headlands are always a source of infection.
4. Sow in moist soil in preference to dry sowing, so that any spores still ungerminated may have a chance to germinate and die before the young crop appears. There is a strong idea amongst farmers that dry ploughing encourages the disease. That is probably true, and for dry sowing also. Early fallowing will induce some of the spores to germinate and die of starvation. Late ploughing, owing to the lack of moisture in the soil, will not cause the discharge of the spores, but simply scatters the perithecia about the paddocks. There they remain protected until the autumn rains cause the discharge of some of the spores. Dry sowing means that the seeds and spores germinate together when the rain comes, and the conditions are thus ideal for infection. Sowing delayed until the ground is moist means that many of the spores will have germinated and died before the young wheat plants have grown sufficiently to be attacked. Dry ploughing and dry sowing should be avoided where there is danger of take-all.
5. Adopt a system of rotation with oats included. This is the most important point of all. In spite of all precautions, spores may survive two years in the soil. By limiting the growth of wheat to one year in four or more, practically all danger of infection, except from spores brought in from outside the cultivated area, is eliminated.

Rotations for the control of Take-all.

The rotations given below are those advised by Mr. G. L. Sutton, Director of Agriculture. They have been proved not only to be effective in the control of take-all, but to be the best for growing wheat, and especially wheat and sheep, in our wheat areas. Where they apparently fail in controlling take-all, the explanation can usually be found in infection from headlands and outside sources, wheat growing in the oat crop, and grasses growing on fallows, or in other troubles being mistaken for take-all.

In order to control this disease and to prevent its occurrence in the wheat crops, it is necessary that some crop which is resistant to take-all, *e.g.*, oats, be grown regularly in rotation with wheat. Such crops are commonly called "change" crops, and in addition to controlling take-all can be used to build up the fertility of light land or maintain that of rich land; for this purpose it is desirable that a certain portion of the cropped area, say one-quarter, or in the case of poor land, one-half, be utilised each year for fodder purposes by grazing. It is not difficult to achieve either or both these objects, if the problem be attacked systematically.

This will require, instead of growing wheat exclusively, that one or more change crops be grown in conjunction with it. If these be grown regularly they will form a rotation, the essential feature being the systematic use of change crops resistant to the disease. Satisfactory rotations can be followed which do not differ materially from the Three course of Fallow, Wheat, Stubble, the only alteration necessary being to substitute "Crops" for Wheat so that the rotation then becomes, Fallow, Crops, Stubble.

Of suitable change crops, oats are the best known and the most widely cultivated. They are admirably suited to the conditions of the West Australian wheat areas. They are useful for light as well as heavy land. They can be used for either grain or hay, and in addition form an admirable fodder or pasture crop.

There are many ways in which this change in fodder crop can be beneficially incorporated in a system of wheat farming.

Hereunder are shown two suitable methods of cropping a paddock affected with take-all. That marked "A" is for a district where it is considered advisable to precede the cereal crop with a fallow, and that marked "B" for a district in which the oat crop can be planted on stubble land:—

	A.	B.
1st year	Wheat with take-all.	Wheat with take-all.
2nd year	Clean fallow.	Clean fallow.
3rd year	Oats.	Oats, grazing crop or stubble.
4th year	Stubble.	Clean fallow.
5th year	Clean fallow.	Wheat.
6th year	Wheat.	Oats, grazing crop or stubble.
7th year	Stubble.	Clean fallow.

Both plans outlined are adaptations of a three-course system, but in "B" an extra fallow is included prior to the rotation proper in order to obtain the time necessary for starving the take-all fungus.

The system of cropping detailed under the "A" method is the three-course system of—1st year fallow, 2nd year crops, 3rd year stubble; in which oats or other change crops are used alternatively with wheat. Where this three-course system is practised in forest land, it is an excellent plan to devote a quarter of the cropped area to oats for grain or hay and a quarter to crops for grazing either in green or mature form, the fodder crop chosen other than oats being also resistant to the disease.

This would provide that half the cropped area would be devoted to change crops. A cropping area of, say, 900 acres would be divided into three approximately equal portions and cropped regularly according to the following scheme:—

CROPPED AREA, 900 ACRES.

	Portion I.	Portion II.	Portion III.
	300 acres.	300 acres.	300 acres.
First year	Fallow	Wheat 150 acres Oats 75 acres Grazing Crop 75 acres	Stubble.
Second year	Wheat 150 acres ... Oats 75 acres Grazing Crop 75 acres	Stubble	Fallow
Third year	Stubble	Fallow	Wheat 150 acres Oats 75 acres Grazing Crop 75 acres

Under this system there would be each year:—

		acres.	acres.
Crop	Wheat	150	
	Oats	75	
	Grazing Crop	75	
			300
Stubbles	Wheat	150	
	Oats	75	
	Grazing Crop	75	
			300
Fallow		300	
			300
	Total		900

So as to derive the full advantage of the change crops—*i.e.*, the oat and grazing crops—in preventing "take-all," the change crops should be arranged so that they are systematically planted over the whole cropping area as in the following scheme, in which one portion of the cropping area in the different years it is under crop is dealt with:—

Area Cropped.	1st time under crop.	2nd time under crop.	3rd time under crop.	4th time under crop.
75 acres	Wheat ...	Oats ...	Wheat ...	Grazing Crop
75 acres	Oats ...	Wheat ...	Grazing Crop	Wheat
75 acres	Wheat ...	Grazing Crop	Wheat ...	Oats
75 acres	Grazing Crop	Wheat ...	Oats ...	Wheat

Where oats or a grazing crop can be sown after wheat without a fallow, as in Scheme "B," the cropping area could be divided into three portions and cropped regularly as hereunder:—

	Portion I.	Portion II.	Portion III.
	300 acres.	300 acres.	300 acres.
First year	Fallow	Wheat	Oats, Grazing Crops and Stubble
Second year	Wheat	Oats, Grazing Crops and Stubble	Fallow
Third year	Oats, Grazing Grops and Stubble	Fallow	Wheat

Under this scheme there would be each year:—

		acres.	acres.
Crop	Wheat		300
	Oats, Grain, say	150	
	Grazing Crops, say	75	
	Stubble, say	75	
			300
Fallow	... ...		300
	Total		900

For farmers who must temporarily continue to grow wheat without a change crop on land affected with take-all, the best course to adopt is to burn the stubble and plough as soon as possible after harvest, and then to plant as late as is safe with a very early maturing variety, such as Florence or Merredin. During the period between ploughing and planting, the land should be thoroughly cultivated to destroy weeds.

The Utilisation of Crops affected by Take-all.

Providing the crop is cut three inches from the ground, there is no danger of spreading the disease by feeding it as hay to stock. By avoiding lower cutting, all the spore cases are left behind on the stubble.

The use of grain from affected crops will not spread the disease. At the same time, such grain being small and shrivelled, is not desirable for seed.

Diseases of Cereals Resembling Take-all.

Other troubles to which cereals are liable are frequently mistaken for take-all. They may occur more or less in patches or be accompanied by a brown discolouration of the lower parts of the stem, the rotting of roots, and the presence of white-heads. Such conditions are often caused by water-logging and the resultant defective aeration of the soil, bad physical and chemical conditions of the soil, and drought.

Bad Drainage.—Badly drained soils may cause the death of plants, owing to there being insufficient air in the soil when the latter is saturated with water. Roots require air to work effectively, and most crop plants are soon injured in its ab-

sence. Soils which puddle and set hard may, simply through their hardness and tendency to crack, seriously check the effectiveness of roots. Such soils also rapidly lose their moisture to the air, so that it is not uncommon for patches, where water lies, to suffer from drought when a dry spell follows rain. Thus a wet winter followed by a dry spring may cause the death of plants from drought in badly drained patches.

Drought.—Early ripening with little or no grain in the heads is a common result of **drought**, particularly in light, fluffy soils.

Frost.—Frost may cause empty ears if heavy frosts occur as the plants are heading. The pollen is affected and grain is not formed in the exposed parts of the head. The lower parts of the ears may escape injury if protected by the leaf sheaths, and may set grain normally.

Salt.

The presence in the soil of **salt** may also produce conditions resembling Take-all. Salt, in the usual meaning of the word in Western Australia, includes Epsom (magnesium sulphate) and Glauber (sodium sulphate), as well as common salt (sodium chloride); the latter being the most plentiful. Its action is two-fold. In the first place, plants are unable to absorb moisture containing a large proportion of dissolved substances, and consequently suffer from shortage of moisture. In the second place, salt has a direct poisoning action on most crop plants. Salt may be present in sufficient quantity to actually prevent the growth of crops, or may be only sufficient to check normal growth. As salt in the surface layers of the soil, where its presence is most serious, is normally greatest in the summer, the autumn rains may wash it down into deeper layers, so that crops may be sown and make good growth until the coming of a dry spell causes the water to rise upward in the soil, bringing the salt with it. Thus salt effects may not be marked until the weather becomes dry and warm.

Other Fungi.

Fungi other than Ophiobilus may cause root rotting and browning of the stem bases, but so far none have been definitely recognised in this State. In the Eastern States, one known as Foot-rot (Helminthosporium sp.) is apparently serious and is under investigation.

The browning of the bases and nodes of the stems may result from any of the previously mentioned causes, but only where fungi are responsible is the dark felted growth found. In the other cases it appears to be simply due to the death of the tissues, the nodes in particular being the most delicate portions of the stem.

As soon as the leaves and other parts commence to die, they are invariably attacked by secondary fungi, especially under moist conditions. These fungi, except under special conditions of moisture, cannot be regarded as important, though they spoil the colour of hay and make it dusty.

SUMMARY.

Take-all, due to the attack of fungi—

- May be distinguished by a dark felted growth at the base of stems of affected plants.
- Attacks wheat, to a lesser extent barley and rye, and barley and spear grasses, but practically never attacks oats.
- Occurs on old and new, fallowed and unfallowed land.

Can be controlled by good farming, which calls for:—

Burning stubble of badly affected crops.
Early fallowing.
Clean fallows and the preparation of a good seed bed.
Wet sowing, together with the use of superphosphate.
Rotation of wheat with oats or other suitable change crops not susceptible to the disease.

The methods of control advised are also the best in the general practice of wheat farming in Western Australia, and their adoption is justified by the increased yields of grain and stock feed which result from their use.

Every infected area is a source of danger to the clean land near by, infection being carried by wind, animals, etc. It is, therefore, to every farmer's interest not only to keep his own land clean but to see that his neighbours do their share also.

Troubles resembling Take-all but due to salt, waterlogging, drought, etc., must be treated by drainage, cultivation, the use of fertilisers, or in other ways rendered advisable by the special conditions.

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